AN ANALYSIS OF THE AQUATIC INVERTEBRATES AND HABITAT OF FIVE STREAMS NEAR HELENA, MONTANA

July-August 2001

A report to

The Montana Department of Environmental Quality
Helena, Montana

by

Wease Bollman
Rhithron Biological Associates
Missoula, Montana

November, 2001

INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in late July and early August 2001 from six sites on five streams near Helena, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Montana Valley and Foothill Prairie ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Montana DEQ personnel from July30-August 1 2001. Six sites on five streams were sampled. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998).

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.
In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present near Helena. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

Table 1. Sampling sites and dates. Six sites on five streams near Helena, Montana.

Site designation	Waterbody	Sampling Date	Location
Silver	Silver Creek	8/1/01	Near mouth
Seven	Seven Mile Creek	7/30/01	Near confluence with Tenmile Creek
Skelly	Skelly Gulch	7/31/01	Uppermost public access to creek
Ten 3	Tenmile Creek	7/31/01	Below confluence with Monitor Creek
Ten 1	Tenmile Creek	7/30/01	At confluence with Seven Mile Creek
Clancy	Clancy Creek	8/1/01	Headwaters

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).

5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In

forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	Score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3a.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric

battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997).	
% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).	
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the 6 sites visited. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

Figure 1. Total habitat assessment scores for sites on streams near Helena, Montana. July-August 2001.

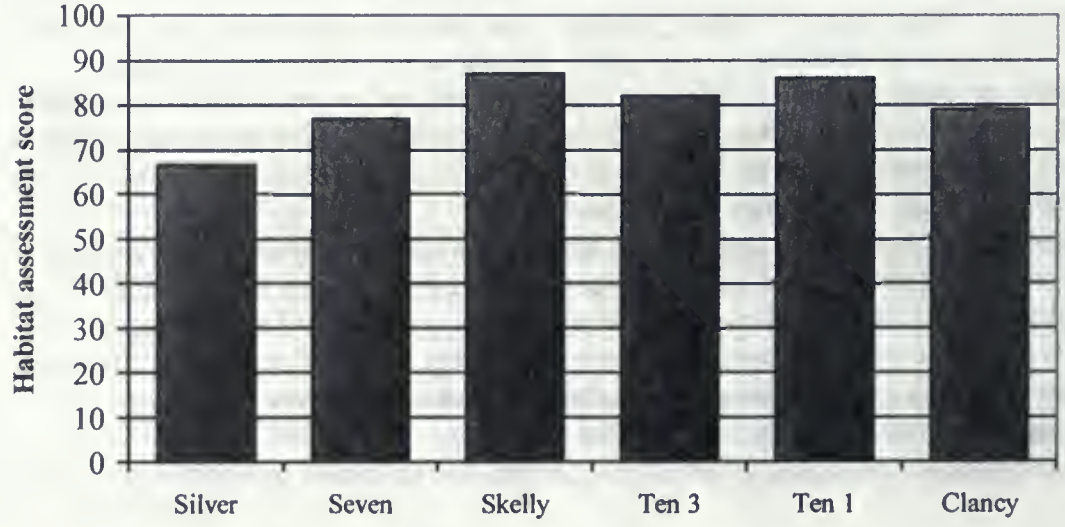


Table 4. Stream and riparian habitat assessment. Four sites (Silver, Seven, Skelly, and Ten 1) were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence, while the assessment for two sites (Ten 3 and Clancy) were based upon criteria developed for streams with glide/pool prevalence. Streams near Helena, July-August 2001.

Max. possible score	Parameter	Silver	Seven	Skelly	Ten 1	Max. possible score	Parameter	Ten 3	Clancy
20	Bottom substrate	20	18	18	20	10	Riffle development	10	10
20	Pool substrate char.	20	18	18	20	10	Benthic substrate	8	8
20	Pool variability	18	11	10	10	20	Embeddedness	11	16
20	Channel alteration	11	18	20	15	20	Channel alteration	18	14
20	Sediment deposition	11	15	18	15	20	Sediment deposition	12	14
20	Channel sinuosity	6	7	10	10	20	Channel flow status	20	20
20	Channel flow status	20	15	20	16	20	Bank stability	10 / 10	8 / 8
20	Bank vegetation	3 / 8	10 / 10	10 / 10	10 / 10	20	Bank vegetation	10 / 10	8 / 8
20	Bank stability	2 / 8	8 / 9	10 / 10	9 / 9	20	Vegetated zone	9 / 9	6 / 6
20	Vegetated zone	1 / 5	6 / 9	10 / 10	10 / 10				
200	Total	133	154	174	164	160	Total	137	126
	Percent of maximum CONDITION*	**66.5 SUB**	**77 OPT**	**87 OPT**	**82 OPT**		Percent of maximum CONDITION*	**86 OPT**	**79 OPT**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1998

Habitat was judged optimal at 5 out of the 6 sites visited; at the Silver Creek site, scores indicated sub-optimal habitat. The channel sinuosity of Silver Creek was perceived to be marginal, although the field investigator suggested that "...stream is utilizing its energy efficiently across entire base flow area" and recommended that no changes to sinuosity be considered in mitigation projects. Streambank vegetative protection was judged marginal on one side of the channel, and bank stability for that side was assessed as poor. The riparian zone width appeared to be abbreviated on both sides of the channel.

At the Seven Mile Creek site, channel sinuosity was judged marginal; other habitat parameters, including all the instream, streambank, and riparian zone assessments, were judged optimal or sub-optimal.

Pool variability was perceived to be marginal at the Skelly Gulch site, with shallow pools more prevalent than deep pools. Channel sinuosity was also perceived to be marginal. All other habitat parameters were assessed as optimal at this site.

Like Skelly Gulch, the downstream site on Tenmile Creek (Ten 1) had marginal pool variability and channel sinuosity with all other parameters rated optimal. At the upstream site (Ten 3), instream, streambank, and riparian parameters were all judged optimal, though road sediments, primarily sand, appeared to impact the benthic substrate.

Other than mild sediment deposition, that may have rendered benthic substrate more monotonous than expected, and some channel alteration, habitat conditions generally scored optimally at the site on Clancy Creek.

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities at the six sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

Figure 2. Total bioassessment scores for six sites near Helena, July-August 2001. Sites are described in Table 1.

Table 5. Metric values, scores, and bioassessments for sites near Helena, July-August 2001. Sites are described in Table 1.

	SITES					
	Silver	Seven	Skelly	Ten 3	Ten 1	Clancy
METRICS	**METRIC VALUES**					
Ephemeroptera richness	3	5	7	6	5	1
Plecoptera richness	0	0	3	6	2	3
Trichoptera richness	2	3	8	3	5	4
Number of sensitive taxa	0	0	3	4	0	1
Percent filterers	2	1	16	0	31	0
Percent tolerant taxa	58	69	2	15	28	7
	METRIC SCORES					
Ephemeroptera richness	1	2	3	3	2	0
Plecoptera richness	0	0	2	3	2	2
Trichoptera richness	1	2	3	2	3	2
Number of sensitive taxa	0	0	2	3	0	1
Percent filterers	3	3	1	3	0	3
Percent tolerant taxa	0	0	3	1	1	2
TOTAL SCORE (max.=18)	5	7	14	15	8	10
PERCENT OF MAX.	**28**	**39**	**78**	**83**	**44**	**56**
Impairment classification*	**MOD**	**MOD**	**SLI**	**NON**	**MOD**	**SLI**
USE SUPPORT †	**PART**	**PART**	**FULL**	**FULL**	**PART**	**PART**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3a.
† Use support designations: See Table 3b.

Based on this analysis of the aquatic invertebrate assemblages, the upper site on Tenmile Creek (Ten 3) fully supported designated uses and exhibited unimpaired biotic health. The site in Skelly Gulch (Skelly) fully supported uses, even though scores suggested slight impairment. At Clancy Creek, slight impairment and partial support of designated uses was indicated by this bioassessment method. Finally, at Silver Creek (Silver), Seven Mile Creek (Seven), and the downstream site on Tenmile Creek (Ten 1), moderate impairment of biotic health and partial support of uses was evident.

Analysis of the Silver Creek sample produced the lowest bioassessment score among the sites visited. There were fewer Ephemeroptera and Trichoptera taxa than expected, and no Plecoptera taxa were collected. Sensitive taxa were absent from the sample, and the proportion of tolerant taxa exceeded expectations.

At Skelly Gulch, most bioassessment metrics gave good scores, but there was a greater abundance of filter-feeders than expected.

No sensitive taxa were collected at the lower site on Tenmile Creek (Ten 1), and both filter-feeders and tolerant taxa were more plentiful than expected. At the upper site (Ten 3), the proportion of tolerant taxa was also high, but Ephemeroptera, Trichoptera, and Plecoptera taxa,

as well as sensitive taxa were all present. This site scored the highest bioassessment score among sites visited.

Clancy Creek supported fewer Ephemeroptera taxa than expected, and only a single sensitive taxon was present in the sample.

Aquatic invertebrate communities

The high modified biotic index value (5.34), coupled with low mayfly taxa richness and high proportion of tolerant taxa, suggests that the water quality of Silver Creek may be impaired. The taxonomic composition of the sample further suggests that water temperature may be elevated, since the leech *Helobdella stagnalis* and 3 genera of snails, including physids, the lymnaeid *Fossaria* sp., and the planorbid *Gyraulus* sp., were present at the studied site. These taxa, along with the caddisfly *Ochrotrichia* sp., which dominated the assemblage, suggest that organic and/or nutrient pollution may also be present. Saprobic conditions and warm water temperatures may have caused anoxic sediments, since 4 taxa of midges taken here are hemoglobin-bearing animals. They include *Chironomus* sp., *Cryptochironomus* sp., *Dicrotendipes* sp., and *Microtendipes* sp. Stoneflies were absent from the sample; lack of these insects may indicate reach-scale habitat disturbance, such as streambank instability, loss of riparian zone function, or disruption of normal channel morphology. Degraded water quality may potentiate the loss of stoneflies as well. Low caddisfly taxa richness was coupled with fewer "clinger" taxa than expected at this site, suggesting that fine sediment deposition compromised benthic habitats. Several taxa of sediment-tolerant animals were abundant at the site, including the midge *Cricotopus bicinctus*, the mayfly *Tricorythodes minutus*, and the caddisfly *Ochrotrichia* sp.

The highest of the modified biotic index scores (6.14) calculated for this study resulted from analysis of the assemblage collected at Seven Mile Creek. Five mayfly taxa were collected at the site, which is only slightly fewer than expected, but which included 2 distinctly tolerant taxa: *Centroptilum* sp. and *Tricorythodes minutus*. Other indications of water quality degradation at this site include the abundance of the scud *Gammarus* sp., which was the most abundant taxon present in the sample, and the high proportion of physid snails. Together, these two taxa comprised 45% of animals in the sample. Sixty-nine percent of creatures in the sample were tolerant taxa. Water quality impairment may be the result of nutrient and/or organic inputs and/or warm water temperatures. Slack water or slowly flowing habitats may have been prevalent at this site, since some taxa that prefer such environments were abundant in the sample; among them were immature corixids as well as mature *Sigara* sp., and the midge *Odontomesa* sp. No stoneflies were taken in the sample, which may imply large-scale disturbances, but which also may be a consequence of water quality impairment. Only 3 caddisfly taxa were collected, and none were abundant; in addition, only 5 "clinger" taxa were present in the sample. This suggests that fine sediment deposition may have obliterated some benthic habitat. Sediment tolerant taxa formed a large proportion of taxa collected.

The modified biotic index value (4.42) calculated for the assemblage sampled at Skelly Gulch was within expectations for an unimpaired valley stream. Seven mayfly taxa and three sensitive taxa (*Kogotus* sp., *Apatania* sp., and *Dolophilodes* sp.) were present in the sample, further suggesting that water quality was good at this site. The assemblage included 3 stonefly taxa, which suggests that reach scale disruptions did not impair biotic health substantially. Eight

caddisfly taxa and 16 "clinger" taxa were part of the mix of animals at the site, suggesting that fine sediment deposition was minimal. All expected functional components of a healthy benthic community were represented, including 5 shredder taxa. This implies that riparian inputs of large organic debris were plentiful.

A mildly elevated modified biotic index value (4.92) suggests that slight impairment of water quality was possible at the lower site on Tenmile Creek (Ten 1). However, the presence of corixids, a haliplid beetle (*Brychius* sp.), and a leech (*Glossiphonia complanata*) in the sample suggests that slack water habitats were sampled along with flowing water habitats, which may cause elevation of the biotic index value. Five mayfly taxa were collected, only slightly fewer than expected, however, no sensitive taxa were present in the sample. Twenty-eight percent of animals in the sample were tolerant taxa. The large proportion of filter-feeders (31%) was comprised solely of the blackfly *Simulium* sp. Large numbers of blackfly larvae in benthic samples may, some biologists suggest, be the result of chance; the gregarious habit of these animals results in a very patchy distribution of large congregations of them, and samplers may randomly encounter such a group. The result can be an overrepresentation of the abundance of *Simulium* sp. in a sample of a benthic assemblage. Their abundance does suggest, however, that fine organic particles in suspension may be plentiful. In any event, the bioassessment result of moderate impairment for this site may be somewhat exaggerated. At the upper site on Tenmile Creek (Ten 3), 6 mayfly taxa were collected, and the modified biotic index value (4.49) was within expectations. This suggests that water quality was good here. Four intolerant taxa contributed to the richness of the assemblage; all are stoneflies: *Zapada columbiana*, *Kogotus* sp., *Megarcys* sp., and *Doroneuria* sp. Six stonefly taxa in all were collected in the sample, suggesting that disturbances to large scale channel morphology or riparian condition did not appreciably affect biotic health. High "clinger" taxa richness implies that fine sediment deposition was not a problem at this site. All functional components of a healthy benthic community were represented in the sample. The bioassessment score calculated for this assemblage was the highest score among visited sites.

Five individuals in a single taxon (*Baetis tricaudatus*) comprised the mayfly fauna at Clancy Creek, casting suspicion on the low biotic index value (2.44) calculated for this site. The calculation appears to have been skewed by the overwhelming dominance of the nemourid stonefly *Amphinemura* sp., which comprised 72% of organisms in the sample. Such a "bloom" of this animal suggests that the site on Clancy Creek may have a large loading of organic debris such as leaves, grass blades, or twigs, or that channel morphology or flow conditions favor the retention of this material. Very small streams with grassy banks are particularly prone to "blooms" of nemourid stoneflies, but whether or not this describes Clancy Creek in the studied reach is not apparent from the data at hand. Water quality may be impaired by nutrients associated with the organic material, resulting in the depression of mayfly taxa richness. Only 4 caddisfly taxa were present in the sample, and only 5 "clinger" taxa were represented; this suggests that impairment of habitats by fine sediment deposition may affect biotic health at this site.

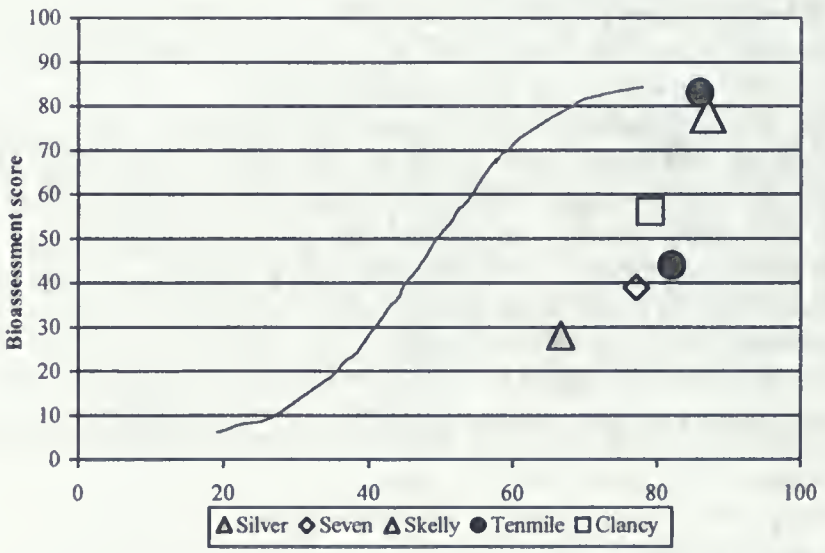
CONCLUSIONS

- Elevated water temperatures and nutrient inputs appear to impair biotic health at the Silver Creek site. In addition, taxonomic composition of the sampled assemblage suggests that

reach-scale disturbances, such as streambank instability or loss of riparian zone function, may further limit benthic biota at the site. Deposition of fine sediments also seems to impact habitat availability.

- Seven Mile Creek may be impaired by nutrient pollution and/or elevated water temperatures. Fine sediment deposition may also limit biotic health in the studied reach.
- Good biotic health is suggested by the taxonomic composition of the assemblage sampled at Skelly Gulch.
- The bioassessment score calculated for the lower Tenmile Creek site (Ten 1) appears to exaggerate impairment. The taxa present in the sample indicate the possibility of mild water quality degradation.
- At the upper Tenmile Creek site (Ten 3), good habitat and good water quality are suggested by the invertebrate assemblage.
- Clancy Creek may have a superabundance of large organic debris. Some indication of elevated nutrient concentration is suggested, and fine sediment deposition may affect the biota at this site as well.
- The relationship between habitat assessment scores and bioassessment scores is illustrated in Figure 3. The red curve in the center of the graph represents the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health (Barbour and Stribling 1991). Symbols that fall below the line indicate that bioassessment scores are somewhat lower than would be expected if impairment were due to habitat degradation alone and suggest that water quality impairment, perhaps by elevated temperatures or elevated nutrient concentrations, was the predominant factor limiting biotic health in these streams.

Figure 3. The relationship of habitat assessment scores and bioassessment scores for sites near Helena, July-August 2001. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health.



LITERATURE CITED

Barbour, M.T., J.B. Stribling and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-79 in W.S. Davis and T.P. Simon (editors) *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton.

Barbour, M.T. and J.B. Stribling. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In: *Biological Criteria: Research and Regulation.* Proceedings of a Symposium, 12-13 December 1990, Arlington, Virginia. EPA-440-5-91-005. U.S. Environmental Protection Agency, Washington, DC.

Bollman, W. 1998. Improving Stream Bioassessment Methods for the Montana Valleys and Foothill Prairies Ecoregion. Unpublished Master's Thesis. University of Montana. Missoula, Montana.

Bukantis, R. 1997. Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOP's. Working draft, April 22, 1997. Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, Montana.

Fore, L.S., J.R. Karr and L.L. Conquest. 1995. Statistical properties of an index of biological integrity used to evaluate water resources. *Canadian Journal of Fisheries and Aquatic Sciences.* 51: 1077-1087.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society* 15(2): 212-231.

Gauch, H. G. 1982. *Multivariate Analysis in Community Ecology.* Cambridge University Press. Cambridge.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist.* 20: 31-39.

Hynes, H.B.N. 1970. *The Ecology of Running Waters.* The University of Toronto Press. Toronto.

Karr, J.R., and E. W. Chu. 1999. *Restoring Life in Running Water: better biological monitoring.* Island Press. Washington, DC.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound Lowland Streams, Washington, USA. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Omernik, J.M. 1997. Level III-Level IV ecoregions of Montana. Unpublished First Draft. August, 1997.

Patterson, A.J. 1996. The effect of recreation on biotic integrity of small streams in Grand Teton National Park. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M.Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rossano, E.M. 1995. Development of an index of biological integrity for Japanese streams (IBI-J). Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Wisseman, R.W. 1992. Montana rapid bioassessment protocols. Benthic invertebrate studies, 1990. Montana Reference Streams study. Report to the Montana Department of Environmental Quality. Water Quality Bureau. Helena, Montana.

Woods, A.J., Omernik, J. M. Nesser, J.A., Shelden, J., and Azevedo, S. H. 1999. Ecoregions of Montana. *(Poster).* Reston, Virginia. USGS.

APPENDIX

Taxonomic data and summaries

Streams near Helena, Montana

July-August 2001

Aquatic Invertebrate Taxonomic Data

Site Name: Silver Creek
Site ID: MO9SLVRC01 8/1/01

Approx. percent of sample used: 3

Taxon	Quantity	Percent	HBI	FFG
Helobdella stagnalis	5	1.66	6	PR
Fossaria sp.	2	0.66	6	CG
Physidae	13	4.32	8	CG
Gyraulus sp.	2	0.66	8	SC
Gammarus sp.	1	0.33	6	CG
Acari	8	2.66	5	PA
Total Misc. Taxa	**31**	**10.30**		
Diphetor hageni	2	0.66	5	CG
Paraleptophlebia sp.	1	0.33	4	CG
Tricorythodes minutus	53	17.61	4	CG
Total Ephemeroptera	**56**	**18.60**		
Hydropsyche sp.	3	1.00	4	CF
Ochrotrichia sp.	77	25.58	4	PH
Total Trichoptera	**80**	**26.58**		
Agabus sp.	1	0.33	5	PR
Dubiraphia sp.	1	0.33	6	CG
Optioservus sp.	13	4.32	4	SC
Total Coleoptera	**15**	**4.98**		
Clinocera sp.	1	0.33	6	PR
Simulium sp.	3	1.00	6	CF
Caloparyphus sp.	2	0.66	8	CG
Dicranota sp.	5	1.66	3	PR
Total Diptera	**11**	**3.65**		
Chironomus sp.	1	0.33	10	CG
Cricotopus Bicinctus Gr.	61	20.27	7	CG
Cricotopus Trifascia Gr.	3	1.00	6	CG
Cryptochironomus sp.	2	0.66	8	PR
Dicrotendipes sp.	5	1.66	8	CG
Eukiefferiella Devonica Gr.	1	0.33	4	OM
Eukiefferiella Pseudomontana Gr.	3	1.00	8	OM
Micropsectra sp.	15	4.98	7	CG
Microtendipes sp.	4	1.33	6	CG
Parametriocnemus sp.	2	0.66	5	CG
Paratanytarsus sp.	1	0.33	6	UN
Potthastia sp.	2	0.66	2	CG
Thienemanniella sp.	4	1.33	6	CG
Thienemannimyia Gr.	4	1.33	6	PR
Total Chironomidae	**108**	**35.88**		
Grand Total	**301**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Silver Creek **Site ID: MO9SLVRC01 8/1/01**

TOTAL ABUNDANCE	301
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	136
TOTAL NUMBER OF TAXA	32
Number EPT taxa	5

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	6	31	10.30
Odonata	0	0	0.00
Ephemeroptera	3	56	18.60
Plecoptera	0	0	0.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	2	80	26.58
Lepidoptera	0	0	0.00
Coleoptera	3	15	4.98
Diptera	4	11	3.65
Chironomidae	14	108	35.88

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.26

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	6	18	5.98
Parasite	1	8	2.66
Collector-gatherer	17	172	57.14
Collector-filterer	2	6	1.99
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	77	25.58
Scraper	2	15	4.98
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	2	4	1.33
Unknown	1	1	0.33

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	2.50
Scraper/(Scraper + C.filterer)	0.71
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Ochrotrichia sp.	77	25.58
Cricotopus Bicinctus Gr.	61	20.27
Tricorythodes minutus	53	17.61
Micropsectra sp.	15	4.98
Physidae	13	4.32
SUBTOTAL 5 DOMINANTS	219	72.76
Optioservus sp.	13	4.32
Acari	8	2.66
Helobdella stagnalis	5	1.66
Dicranota sp.	5	1.66
Dicrotendipes sp.	5	1.66
TOTAL DOMINANTS	255	84.72

SAPROBIC INDICES

Hilsenhoff Biotic Index	5.34

DIVERSITY MEASURES

Shannon H (loge)	2.44
Shannon H (log2)	3.52
Evenness	0.70
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	149	49.50
Univoltine	137	45.51
Semivoltine	15	4.98

	#TAXA	ABUNDANCE	PERCENT
Tolerant	14	176	58.47
Intolerant	0	0	0.00
Clinger	8	162	53.82

Aquatic Invertebrate Taxonomic Data

Site Name: Seven Mile Creek
Site ID: MO9SVNMC01 7/30/01

Approx. percent of sample used: 17

Taxon	Quantity	Percent	HBI	FFG
Polycelis coronata	1	0.31	4	CG
Ophidonais serpentina	7	2.17	6	CG
Eiseniella tetraedra	3	0.93	8	CG
Sphaeriidae	17	5.26	8	CG
Fossaria sp.	2	0.62	6	CG
Physidae	55	17.03	8	CG
Gammarus sp.	92	28.48	6	CG
Total Misc. Taxa	**177**	**54.80**		
Ophiogomphus sp.	2	0.62	4	PR
Enallagma sp.	1	0.31	9	PR
Total Odonata	**3**	**0.93**		
Baetis tricaudatus	10	3.10	6	CG
Centroptilum sp.	2	0.62	2	CG
Diphetor hageni	16	4.95	5	CG
Labiobaetis sp.	2	0.62	4	CG
Tricorythodes minutus	38	11.76	4	CG
Total Ephemeroptera	**68**	**21.05**		
Corixidae - immature	28	8.67	8	UN
Sigara sp.	1	0.31	8	PH
Total Hemiptera	**29**	**8.98**		
Helicopsyche borealis	1	0.31	7	SC
Hydroptila sp.	2	0.62	6	PH
Onocosmoecus unicolor	1	0.31	1	OM
Total Trichoptera	**4**	**1.24**		
Stichtotarsus sp.	2	0.62	5	PR
Optioservus sp.	14	4.33	4	SC
Zaitzevia sp.	1	0.31	4	CG
Total Coleoptera	**17**	**5.26**		
Simulium sp.	3	0.93	6	CF
Total Diptera	**3**	**0.93**		
Cryptochironomus sp.	3	0.93	8	PR
Odontomesa sp.	8	2.48	4	CG
Paratanytarsus sp.	1	0.31	6	UN
Radotanypus sp.	5	1.55	4	PR
Thienemannimyia Gr.	5	1.55	6	PR
Total Chironomidae	**22**	**6.81**		
Grand Total	**323**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Seven Mile Creek **Site ID: MO9SVNMC01 7/30/01**

TOTAL ABUNDANCE	323
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	72
TOTAL NUMBER OF TAXA	28
Number EPT taxa	8

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	7	177	54.80
Odonata	2	3	0.93
Ephemeroptera	5	68	21.05
Plecoptera	0	0	0.00
Hemiptera	2	29	8.98
Megaloptera	0	0	0.00
Trichoptera	3	4	1.24
Lepidoptera	0	0	0.00
Coleoptera	3	17	5.26
Diptera	1	3	0.93
Chironomidae	5	22	6.81

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	3.27

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	6	18	5.57
Parasite	0	0	0.00
Collector-gatherer	14	254	78.64
Collector-filterer	1	3	0.93
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	2	3	0.93
Scraper	2	15	4.64
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	1	1	0.31
Unknown	2	29	8.98

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	5.00
Scraper/(Scraper + C.filterer)	0.83
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Gammarus sp.	92	28.48
Physidae	55	17.03
Tricorythodes minutus	38	11.76
Corixidae - immature	28	8.67
Sphaeriidae	17	5.26
SUBTOTAL 5 DOMINANTS	230	71.21
Diphetor hageni	16	4.95
Optioservus sp.	14	4.33
Baetis tricaudatus	10	3.10
Odontomesa sp.	8	2.48
Ophiodonais serpentina	7	2.17
TOTAL DOMINANTS	285	88.24

SAPROBIC INDICES

Hilsenhoff Biotic Index	6.14

DIVERSITY MEASURES

Shannon H (loge)	2.06
Shannon H (log2)	2.97
Evenness	0.62
Simpson D	0.12

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	42	12.85
Univoltine	254	78.64
Semivoltine	28	8.51

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	222	68.73
Intolerant	0	0	0.00
Clinger	5	21	6.50

Aquatic Invertebrate Taxonomic Data

Site Name: Skelly Gulch
Site ID: MO9SKLYG01 7/31/01

Approx. percent of sample used: 53

Taxon	Quantity	Percent	HBI	FFG
Polycelis coronata	7	2.10	4	CG
Eiseniella tetraedra	37	11.11	8	CG
Sphaeriidae	33	9.91	8	CG
Total Misc. Taxa	**77**	**23.12**		
Baetis tricaudatus	3	0.90	6	CG
Diphetor hageni	1	0.30	5	CG
Serratella tibialis	5	1.50	2	CG
Epeorus longimanus	9	2.70	1	SC
Nixe sp.	3	0.90	2	SC
Paraleptophlebia sp.	1	0.30	4	CG
Tricorythodes minutus	1	0.30	4	CG
Total Ephemeroptera	**23**	**6.91**		
Sweltsa sp.	2	0.60	1	PR
Amphinemura sp.	16	4.80	2	SH
Kogotus sp.	1	0.30	2	PR
Total Plecoptera	**19**	**5.71**		
Arctopsyche grandis 39% OF HYDROPSYCHIDAE →	23	6.91	1	PR
Micrasema sp.	1	0.30	1	MH
Glossosoma sp.	16	4.80	1	SC
Lepidostoma sp.-panel case larvae	4	1.20	1	SH
Lepidostoma sp.-turret case larvae	1	0.30	2	SH
Apatania sp.	5	1.50	1	SC
Dolophilodes sp.	7	2.10	2	CF
Rhyacophila Brunnea Gr.	2	0.60	1	PR
Total Trichoptera	**59**	**17.72**		
Cleptelmis addenda	4	1.20	4	CG
Heterlimnius sp.	81	24.32	4	CG
Lara avara	6	1.80	4	SH
Narpus sp.	5	1.50	4	CG
Total Coleoptera	**96**	**28.83**		
Forcipomyiinae	1	0.30	6	PR
Simulium sp.	9	2.70	6	CF
Tipula sp.	2	0.60	4	OM
Total Diptera	**12**	**3.60**		
Brillia sp.	3	0.90	5	SH
Pagastia sp.	1	0.30	1	CG
Paratanytarsus sp.	5	1.50	6	UN
Rheotanytarsus sp.	36	10.81	6	CF
Tvetenia sp.	2	0.60	5	CG
Total Chironomidae	**47**	**14.11**		
Grand Total	**333**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Skelly Gulch **Site ID: MO9SKLYG01 7/31/01**

TOTAL ABUNDANCE	333
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	101
TOTAL NUMBER OF TAXA	33
Number EPT taxa	18

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	77	23.12
Odonata	0	0	0.00
Ephemeroptera	7	23	6.91
Plecoptera	3	19	5.71
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	8	59	17.72
Lepidoptera	0	0	0.00
Coleoptera	4	96	28.83
Diptera	3	12	3.60
Chironomidae	5	47	14.11

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	2.15

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	29	8.71
Parasite	0	0	0.00
Collector-gatherer	13	181	54.35
Collector-filterer	3	52	15.62
Macrophyte-herbivore	1	1	0.30
Piercer-herbivore	0	0	0.00
Scraper	4	33	9.91
Shredder	5	30	9.01
Xylophage	0	0	0.00
Omnivore	1	2	0.60
Unknown	1	5	1.50

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.63
Scraper/(Scraper + C.filterer)	0.39
Shredder/Total organisms	0.03

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Heterlimnius sp.	81	24.32
Eiseniella tetraedra	37	11.11
Rheotanytarsus sp.	36	10.81
Sphaeriidae	33	9.91
Arctopsyche grandis	23	6.91
SUBTOTAL 5 DOMINANTS	210	63.06
Amphinemura sp.	16	4.80
Glossosoma sp.	16	4.80
Epeorus longimanus	9	2.70
Simulium sp.	9	2.70
Polycelis coronata	7	2.10
TOTAL DOMINANTS	267	80.18

SAPROBIC INDICES

Hilsenhoff Biotic Index	4.42

DIVERSITY MEASURES

Shannon H (loge)	2.35
Shannon H (log2)	3.39
Evenness	0.67
Simpson D	0.09

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	45	13.59
Univoltine	151	45.42
Semivoltine	137	40.99

	#TAXA	ABUNDANCE	PERCENT
Tolerant	3	8	2.40
Intolerant	3	13	3.90
Clinger	16	213	63.96

Aquatic Invertebrate Taxonomic Data

Site Name: Ten Mile Creek
Site ID: MO9TENMC01 7/30/01

Approx. percent of sample used: 17

Taxon	Quantity	Percent	HBI	FFG
Ophidonais serpentina	1	0.30	6	CG
Tubificidae - immature	1	0.30	9	CG
Glossiphonia complanata	1	0.30	6	PR
Sphaeriidae	4	1.19	8	CG
Ferrissia sp.	2	0.60	6	SC
Physidae	1	0.30	8	CG
Gyraulus sp.	1	0.30	8	SC
Acari	5	1.49	5	PA
Total Misc. Taxa	**16**	**4.78**		
Baetis tricaudatus	17	5.07	6	CG
Diphetor hageni	17	5.07	5	CG
Nixe sp.	27	8.06	2	SC
Paraleptophlebia debilis	16	4.78	4	CG
Tricorythodes minutus	29	8.66	4	CG
Total Ephemeroptera	**106**	**31.64**		
Skwala sp.	3	0.90	2	PR
Pteronarcys sp. - early instars	1	0.30	0	OM
Total Plecoptera	**4**	**1.19**		
Corixidae - immature	3	0.90	8	UN
Sigara sp.	1	0.30	8	PH
Total Hemiptera	**4**	**1.19**		
Arctopsychinae - early instars	10	2.99	2	PR
Hydroptila sp.	1	0.30	6	PH
Lepidostoma sp.-panel case larvae	1	0.30	1	SH
Lepidostoma sp.-turret case larvae	1	0.30	2	SH
Psychoglypha subborealis	1	0.30	2	OM
Total Trichoptera	**14**	**4.18**		
Dytiscidae - larvae	2	0.60	5	PR
Stichtotarsus sp.	1	0.30	5	PR
Heterlimnius sp.	6	1.79	4	CG
Optioservus sp.	11	3.28	4	SC
Zaitzevia sp.	25	7.46	4	CG
Brychius sp.	1	0.30	5	MH
Total Coleoptera	**46**	**13.73**		
Simulium sp.	105	31.34	6	CF
Hexatoma sp.	4	1.19	2	PR
Total Diptera	**109**	**32.54**		
Eukiefferiella Pseudomontana Gr.	3	0.90	8	OM
Micropsectra sp.	6	1.79	7	CG
Orthocladius sp.	13	3.88	6	CG
Parametriocnemus sp.	1	0.30	5	CG
Thienemannimyia Gr.	13	3.88	6	PR
Total Chironomidae	**36**	**10.75**		
Grand Total	**335**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Ten Mile Creek **Site ID: MO9TENMC01 7/30/01**

TOTAL ABUNDANCE	335
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	124
TOTAL NUMBER OF TAXA	35
Number EPT taxa	12

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	8	16	4.78
Odonata	0	0	0.00
Ephemeroptera	5	106	31.64
Plecoptera	2	4	1.19
Hemiptera	2	4	1.19
Megaloptera	0	0	0.00
Trichoptera	5	14	4.18
Lepidoptera	0	0	0.00
Coleoptera	6	46	13.73
Diptera	2	109	32.54
Chironomidae	5	36	10.75

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	3.44

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	7	34	10.15
Parasite	1	5	1.49
Collector-gatherer	13	137	40.90
Collector-filterer	1	105	31.34
Macrophyte-herbivore	1	1	0.30
Piercer-herbivore	2	2	0.60
Scraper	4	41	12.24
Shredder	2	2	0.60
Xylophage	0	0	0.00
Omnivore	3	5	1.49
Unknown	1	3	0.90

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.39
Scraper/(Scraper + C.filterer)	0.28
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Simulium sp.	105	31.34
Tricorythodes minutus	29	8.66
Nixe sp.	27	8.06
Zaitzevia sp.	25	7.46
Baetis tricaudatus	17	5.07
SUBTOTAL 5 DOMINANTS	203	60.60
Diphetor hageni	17	5.07
Paraleptophlebia debilis	16	4.78
Orthocladius sp.	13	3.88
Thienemannimyia Gr.	13	3.88
Optioservus sp.	11	3.28
TOTAL DOMINANTS	273	81.49

SAPROBIC INDICES

Hilsenhoff Biotic Index	4.92

DIVERSITY MEASURES

Shannon H (loge)	2.27
Shannon H (log2)	3.28
Evenness	0.64
Simpson D	0.11

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	58	17.39
Univoltine	218	65.00
Semivoltine	59	17.61

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	94	28.06
Intolerant	0	0	0.00
Clinger	8	186	55.52

Aquatic Invertebrate Taxonomic Data

Site Name: Ten Mile Creek
Site ID: MO9TENMC03 7/31/01

Approx. percent of sample used: 100

Taxon	Quantity	Percent	HBI	FFG
Baetis tricaudatus	26	14.36	6	CG
Drunella coloradensis	7	3.87	0	CG
Serratella tibialis	9	4.97	2	CG
Cinygmula sp.	8	4.42	4	SC
Epeorus albertae	3	1.66	1	SC
Ameletus sp.	9	4.97	0	CG
Total Ephemeroptera	**62**	**34.25**		
Sweltsa sp.	2	1.10	1	PR
Zapada cinctipes	1	0.55	2	SH
Zapada columbiana	3	1.66	2	SH
Doroneuria sp.	4	2.21	1	PR
Kogotus sp.	2	1.10	2	PR
Megarcys sp.	2	1.10	2	PR
Total Plecoptera	**14**	**7.73**		
Glossosoma sp.	4	2.21	1	SC
Rhyacophila Betteni Gr.	1	0.55	1	PR
Rhyacophila Brunnea Gr.	3	1.66	1	PR
Total Trichoptera	**8**	**4.42**		
Heterlimnius sp.	21	11.60	4	CG
Narpus sp.	1	0.55	4	CG
Total Coleoptera	**22**	**12.15**		
Chelifera sp.	2	1.10	6	PR
Hexatoma sp.	1	0.55	2	PR
Tipula sp.	4	2.21	4	OM
Total Diptera	**7**	**3.87**		
Brillia sp.	1	0.55	5	SH
Cricotopus (Isocladius) Gr.	1	0.55	7	CG
Eukiefferiella Pseudomontana Gr.	1	0.55	8	OM
Micropsectra sp.	56	30.94	7	CG
Orthocladius sp.	1	0.55	6	CG
Stempellinella sp.	3	1.66	4	UN
Thienemannimyia Gr.	1	0.55	6	PR
Tvetenia sp.	4	2.21	5	CG
Total Chironomidae	**68**	**37.57**		
Grand Total	**181**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Ten Mile Creek **Site ID: MO9TENMC03 7/31/01**

TOTAL ABUNDANCE	181
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	84
TOTAL NUMBER OF TAXA	28
Number EPT taxa	15

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	0	0	0.00
Odonata	0	0	0.00
Ephemeroptera	6	62	34.25
Plecoptera	6	14	7.73
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	3	8	4.42
Lepidoptera	0	0	0.00
Coleoptera	2	22	12.15
Diptera	3	7	3.87
Chironomidae	8	68	37.57

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.24

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	9	18	9.94
Parasite	0	0	0.00
Collector-gatherer	10	135	74.59
Collector-filterer	0	0	0.00
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	3	15	8.29
Shredder	3	5	2.76
Xylophage	0	0	0.00
Omnivore	2	5	2.76
Unknown	1	3	1.66

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	1.00
Shredder/Total organisms	0.02

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Micropsectra sp.	56	30.94
Baetis tricaudatus	26	14.36
Heterlimnius sp.	21	11.60
Serratella tibialis	9	4.97
Ameletus sp.	9	4.97
SUBTOTAL 5 DOMINANTS	121	66.85
Cinygmula sp.	8	4.42
Drunella coloradensis	7	3.87
Doroneuria sp.	4	2.21
Glossosoma sp.	4	2.21
Tipula sp.	4	2.21
TOTAL DOMINANTS	148	81.77

SAPROBIC INDICES

Hilsenhoff Biotic Index	4.49

DIVERSITY MEASURES

Shannon H (loge)	2.52
Shannon H (log2)	3.64
Evenness	0.76
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	71	38.95
Univoltine	83	45.58
Semivoltine	28	15.47

	#TAXA	ABUNDANCE	PERCENT
Tolerant	2	27	14.92
Intolerant	4	11	6.08
Clinger	12	62	34.25

Aquatic Invertebrate Taxonomic Data

Site Name: Clancy Creek
Site ID: MO9CLNCC01 8/1/01

Approx. percent of sample used: 23

Taxon	Quantity	Percent	HBI	FFG
Polycelis coronata	1	0.32	4	CG
Total Misc. Taxa	**1**	**0.32**		
Baetis tricaudatus	5	1.58	6	CG
Total Ephemeroptera	**5**	**1.58**		
Chloroperlidae - early instars	4	1.27	1	PR
Amphinemura sp.	228	72.15	2	SH
Doroneuria sp.	5	1.58	1	PR
Total Plecoptera	**237**	**75.00**		
Arctapsyche grandis ✓	10	3.16	1	PR
Micrasema sp.	10	3.16	1	MH
Lepidostoma sp.-sand case larvae	1	0.32	1	SH
Dicosmoecus gilvipes	1	0.32	2	SC
Total Trichoptera	**22**	**6.96**		
Oreodytes sp.	16	5.06	5	PR
Narpus sp.	4	1.27	4	CG
Optioservus sp.	1	0.32	4	SC
Total Coleoptera	**21**	**6.65**		
Tipula sp.	1	0.32	4	OM
Total Diptera	**1**	**0.32**		
Cricotopus Bicinctus Gr.	5	1.58	7	CG
Eukiefferiella Brehmi Gr.	7	2.22	4	OM
Micropsectra sp.	1	0.32	7	CG
Pagastia sp.	4	1.27	1	CG
Parametriocnemus sp.	1	0.32	5	CG
Rheocricotopus sp.	10	3.16	6	OM
Thienemannimyia Gr.	1	0.32	6	PR
Total Chironomidae	**29**	**9.18**		
Grand Total	**316**	**100.00**		

Aquatic Invertebrate Summary Data

Site Name: Clancy Creek **Site ID: MO9CLNCC01 8/1/01**

TOTAL ABUNDANCE	316
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	264
TOTAL NUMBER OF TAXA	20
Number EPT taxa	8

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	1	1	0.32
Odonata	0	0	0.00
Ephemeroptera	1	5	1.58
Plecoptera	3	237	75.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	4	22	6.96
Lepidoptera	0	0	0.00
Coleoptera	3	21	6.65
Diptera	1	1	0.32
Chironomidae	7	29	9.18

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	9.10

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	36	11.39
Parasite	0	0	0.00
Collector-gatherer	7	21	6.65
Collector-filterer	0	0	0.00
Macrophyte-herbivore	1	10	3.16
Piercer-herbivore	0	0	0.00
Scraper	2	2	0.63
Shredder	2	229	72.47
Xylophage	0	0	0.00
Omnivore	3	18	5.70
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	#DIV/0!
Scraper/(Scraper + C.filterer)	1.00
Shredder/Total organisms	0.23

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Amphinemura sp.	228	72.15
Oreodytes sp.	16	5.06
Arctopsyche grandis	10	3.16
Micrasema sp.	10	3.16
Rheocricotopus sp.	10	3.16
SUBTOTAL 5 DOMINANTS	274	86.71
Eukiefferiella Brehmi Gr.	7	2.22
Baetis tricaudatus	5	1.58
Doroneuria sp.	5	1.58
Cricotopus Bicinctus Group	4	1.27
Pagastia sp.	4	1.27
TOTAL DOMINANTS	291	92.09

SAPROBIC INDICES

Hilsenhoff Biotic Index	2.44

DIVERSITY MEASURES

Shannon H (loge)	0.95
Shannon H (log2)	1.37
Evenness	0.32
Simpson D	0.42

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	27	8.39
Univoltine	253	80.06
Semivoltine	37	11.55

	#TAXA	ABUNDANCE	PERCENT
Tolerant	3	22	6.96
Intolerant	1	5	1.58
Clinger	5	30	9.49

Macroinvertebrate Bioassessment using MDEQ's 1998 Intermountain Valley and Foothill Ecoregion Criteria

Waterbody(s):	**Addendum Prepared by Alan Nixon 01/15/02**

Skelly Gulch Cr

Table 1. Benthic macroinvertebrate metric analysis.

Site:	M09SKLYG01						
Date:	7/31/2001						
Taxa Richness	33						
EPT Richness	18						
Biotic Index	4.420						
% Dominant Taxon	24.32						
% Collectors (g+ff)	69.97						
% Scrapers and Shredders	18.92						
% Hydropsychinae of Trichoptera	0						
% EPT	30.33						

Table 2. Benthic macroinvertebrate data scoring using MDEQ's Intermountain Valley and Foothill Ecoregion criteria.

Site:	M09SKLYG01						
Taxa Richness	3						
EPT Richness	3						
Biotic Index	2						
% Dominant Taxon	3						
% Collectors (g+ff)	3						
% Scrapers and Shredders	1						
% Hydropsychinae of Trichoptera	3						
% EPT	1						
Totals	19	0	0	0	0	0	0
Scored percentages	**79.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Macroinvertebrate Bioassessment using MDEQ's 1998 Intermountain Valley and Foothill Ecoregion Criteria

Waterbody(s):	**Addendum Prepared by Alan Nixon 01/18/02**

Clancy Creek

Table 1. Benthic macroinvertebrate metric analysis.

Site:	M09CLNCC01						
Date:	8/1/2001						
Taxa Richness	20						
EPT Richness	8						
Biotic Index	2.440						
% Dominant Taxon	72.15						
% Collectors (g+ff)	6.65						
% Scrapers and Shredders	73.1						
% Hydropsychinae of Trichoptera	0						
% EPT	83.54						

Table 2. Benthic macroinvertebrate data scoring using MDEQ's Intermountain Valley and Foothill Ecoregion criteria.

Site:	M09CLNCC01						
Taxa Richness	1						
EPT Richness	0						
Biotic Index	3						
% Dominant Taxon	0						
% Collectors (g+ff)	3						
% Scrapers and Shredders	3						
% Hydropsychinae of Trichoptera	3						
% EPT	3						
Totals	16	0	0	0	0	0	0
Scored percentages	66.7	0.0	0.0	0.0	0.0	0.0	0.0